

In the Claims

1. (currently amended) A method of adhering a ruthenium metal layer to an oxide layer of a semiconductor device, comprising:
 - forming an oxide layer;
 - exposing the oxide layer to a compound consisting essentially of a silicon-containing gas selected from the group consisting of ~~silane, disilane~~ SiH_4 , Si_2H_6 , and methylated silanes; and
 - after exposing the oxide layer to the silicon-containing gas and without substantial prior exposure of the oxide layer to oxygen, forming a ruthenium metal layer to contact the oxide layer.
2. (original) The method of claim 1 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.
3. (original) The method of claim 1 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.
4. (currently amended) A method of adhering a ruthenium metal layer to an oxide layer of a semiconductor device, comprising:
 - forming an oxide layer;
 - exposing the oxide layer to a compound consisting essentially of a silicon-containing gas selected from the group consisting of ~~silane, disilane~~ SiH_4 , Si_2H_6 , and methylated silanes; to convert a surface termination of the oxide layer from a hydroxyl-terminated surface to a hydrogen-terminated surface; and
 - after exposing the oxide layer to the silicon-containing gas and without substantial prior exposure of the oxide layer to oxygen, forming a ruthenium metal layer to contact the oxide layer.
5. (original) The method of claim 4 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.

6. (original) The method of claim 4 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.

7. (currently amended) A method for forming a semiconductor device, comprising:

providing an oxide layer as part of a semiconductor wafer substrate assembly;

placing the semiconductor wafer substrate assembly into a deposition chamber;

flowing a compound consisting essentially of a silicon-containing gas selected from the group consisting of silane, ~~disilane~~ SiH_4 , Si_2H_6 , and methylated silanes into the deposition chamber to expose the oxide layer to the silicon-containing gas; and

subsequent to exposing the oxide layer to the silicon-containing gas and without substantial prior exposure of the oxide layer to oxygen, flowing a ruthenium metal precursor into the deposition chamber to form a ruthenium metal layer on the oxide layer.

8. (canceled)

9. (original) The method of claim 7 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene.

10. (original) The method of claim 7 further comprising flowing helium into the deposition chamber concurrently during the flowing of the ruthenium metal precursor into the deposition chamber.

11. (original) The method of claim 7 wherein the oxide layer is silicon dioxide.

12. (original) The method of claim 7 wherein the oxide layer comprises an oxide selected from the group consisting of metal oxide and mixed metal oxide.

13. (original) The method of claim 7 wherein the oxide layer comprises an oxide selected from the group consisting of hafnium oxide, aluminum oxide, tantalum pentoxide, barium strontium titanate, titanium oxide, yttrium aluminum oxide, and aluminum hafnium oxide.

14. (original) The method of claim 7 further comprising maintaining a thickness of the oxide layer such that subsequent to the exposure of the oxide layer to the silicon-containing gas the oxide layer is not thicker than prior to the exposure to the silicon-containing gas, and the exposure to the silicon-containing gas does not form a separate layer of material on the oxide layer.

15. (original) The method of claim 7 further comprising forming the ruthenium metal layer 60 minutes or less after exposing the oxide layer to the silicon-containing gas.

16. (original) The method of claim 7 further comprising forming the ruthenium metal layer 10 minutes or less after exposing the oxide layer to the silicon-containing gas.

17. (previously presented) The method of claim 7 further comprising:

 flowing the ruthenium metal precursor into the deposition chamber for a duration of between about 0.1 milliseconds and about 10 seconds;

 subsequent to flowing the ruthenium metal precursor into the deposition chamber, purging the ruthenium metal precursor from the chamber for between about 1 second and about 60 seconds; then

repeating the flow of the ruthenium metal precursor into the deposition chamber and the purging of the ruthenium metal precursor from the chamber a sufficient number of times to form the ruthenium metal layer of a sufficient thickness.

18. (original) The method of claim 17 further comprising performing the flow of the ruthenium metal precursor into the deposition chamber and the purge of the ruthenium metal precursor from the chamber for between about 10 cycles and about 300 cycles.

19. (currently amended) A method used to form a storage capacitor for a semiconductor device, comprising:

providing a semiconductor wafer substrate assembly comprising a conductive contact pad and a planarized oxide layer over the conductive contact pad;

etching the oxide layer to expose the conductive contact pad;

in a deposition chamber, flowing a silicon-containing gas to expose the oxide layer to the silicon-containing gas, wherein the exposure of the oxide layer to the silicon-containing is conducted in an environment such that the exposure to the silicon-containing gas does not add additional thickness to the oxide layer; and

subsequent to exposing the oxide layer to the silicon-containing gas and without substantial prior exposure to oxygen, flowing a ruthenium metal precursor into the deposition chamber to form a ruthenium metal layer on the oxide layer and on the conductive contact pad.

20. (currently amended) The method of claim 19 wherein the flowing of the silicon-containing gas into the deposition chamber comprises flowing a gas selected from the group consisting of ~~silane, disilane~~ SiH_4 , Si_2H_6 , and methylated silanes.

21. (original) The method of claim 20 further comprising:

flowing the silicon-containing gas into the deposition chamber at a flow rate of between about 1 standard cubic centimeter per minute (sccm) and about 100 sccm;

maintaining the semiconductor wafer substrate assembly at a temperature of between about 150°C and about 350°C during the flow of the silicon-containing gas into the deposition chamber; and

flowing the silicon-containing gas into the deposition chamber for a duration of between about 10 seconds and about 120 seconds.

22. (original) The method of claim 19 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene.

23. (original) The method of claim 19 wherein the flowing of the ruthenium metal precursor into the deposition chamber comprises flowing a gas selected from the group consisting essentially of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and derivatives of ruthenocene.

24. (original) The method of claim 19 further comprising forming a ruthenium metal layer between about 50 angstroms (Å) and about 200 Å during the flow of the ruthenium metal precursor into the deposition chamber.

25. (original) The method of claim 24 further comprising:

flowing the ruthenium metal precursor into the deposition chamber at a flow rate of between about 0 standard cubic centimeters per minute (sccm) and about 1,000 sccm;

maintaining the semiconductor wafer substrate assembly at a temperature of between about 100 °C and about 500 °C during the flow of the ruthenium metal precursor into the deposition chamber;

maintaining the deposition chamber at a pressure of between about 1 Torr and about 5 Torr during the flow of the ruthenium metal precursor into the deposition chamber; and

flowing the ruthenium metal precursor into the deposition chamber for a duration of between about 30 seconds and about 8 minutes.

26. (currently amended) A method used to form a semiconductor device, comprising:

providing a semiconductor wafer substrate assembly comprising an oxide layer having a hydroxyl-terminated surface termination;

placing the semiconductor wafer substrate assembly into a deposition chamber;

in the deposition chamber, exposing the oxide layer to a silicon-containing gas selected from the group consisting of silane, ~~disilane~~ SiH₄, Si₂H₆, and methylated silanes to alter the surface termination from the hydroxyl-termination to a hydrogen-terminated surface termination; and

within 60 minutes or less of exposing the oxide layer to the silicon-containing gas, and within the deposition chamber and without substantial prior exposure of the oxide layer to oxygen, exposing the oxide layer to a ruthenium metal precursor selected from the group consisting of tricarbonyl cyclohexadiene ruthenium, bis(cyclopentadienyl) ruthenium, and a derivative of ruthenocene to form a ruthenium metal layer on at least the portion of the oxide layer exposed to the silicon-containing gas.

27. (previously presented) The method of claim 19 wherein the exposure of the oxide layer to the silicon-containing gas does not result in the formation of another layer over the oxide layer.

28. (previously presented) The method of claim 26 wherein the exposure of the oxide layer to the silicon-containing gas does not add to the thickness of the oxide layer.

29. (previously presented) The method of claim 26 wherein the exposure of the oxide layer to the silicon-containing gas does not result in the formation of another layer over the oxide layer.

30. (currently amended) A method of adhering a ruthenium metal layer to an oxide layer of a semiconductor device, comprising:

forming an oxide layer;

exposing the oxide layer to a silicon-containing gas selected from the group consisting of ~~silane, disilane~~ SiH_4 , Si_2H_6 , and methylated silanes, wherein the exposure to the silicon-containing gas is conducted in an environment such that the exposure of the oxide layer to the silicon-containing gas does not add additional thickness to the oxide layer; and

after exposing the oxide layer to the silicon-containing gas and without substantial prior exposure to oxygen, forming a ruthenium metal layer to contact the oxide layer.

31. (previously presented) The method of claim 30 wherein the exposure of the oxide layer to the silicon-containing gas does not result in the formation of another layer on the oxide layer.

32. (new) The method of claim 7 wherein the ruthenium metal layer is formed after exposing the oxide layer to the silicon-containing gas without prior exposure of the oxide layer to a dopant.

33. (new) The method of claim 19 wherein the ruthenium metal layer is formed after exposing the oxide layer to the silicon-containing gas without prior exposure of the oxide layer to a dopant.

34. (new) The method of claim 26 wherein the ruthenium metal layer is formed after exposing the oxide layer to the silicon-containing gas without prior exposure of the oxide layer to a dopant.

35. (new) The method of claim 30 wherein the ruthenium metal layer is formed after exposing the oxide layer to the silicon-containing gas without prior exposure of the oxide layer to a dopant.